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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF THE DIMENSIONAL ACCURACY OF THREE DIFFERENT IRREVERSIBLE HYDROCOLLOID IMPRESSION MATERIALS AT DIFFERENT STORAGE PERIODS - AN INVITRO STUDY

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ABSTRACT

Purpose: The purpose of the study was to compare the dimensional stability of three different alginate impression materials at three different storage periods.

Materials and Methods: A brass model representing maxillary edentulous ridge was used as a master model in this study. Three customised abutments A,B,C were CAD/CAM machined to simulate full veneer preparation. They were positioned on the master model one in the anterior region and two in the posterior region on either side of the ridge. The centre of the cross hair reference lines made on the occlusal surfaces of abutments was used for measuring linear dimensional changes. A total of 90 impressions of the master model was made by all three irreversible hydrocolloids and stored in three different storage period of 30 minutes, 12 hours and 24 hours. The casts were poured after three storage period with type IV gypsum product and the inter abutment distance between the abutments were measured with the electronic vernier caliper.

Results: ANOVA analysis showed no significant differences ($p < .05$) at 30 minutes storage period between all three alginates and a very high significant difference ($p < .001$) at 12 and 24 hours storage periods.

Conclusion: The dimensional accuracy of the improvised alginates Cavex CA37 and Neocolloid were greater than the conventional Algitex in delayed pouring of the cast.

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INTRODUCTION

Making an impression is the first step towards fabrication of a prosthesis. Irreversible hydrocolloid, commonly called as alginate is a viscoelastic material that was developed in 1940 during world war II. (Alka Patwa *et al.*, 2012; Ekanem and Akeredolu, 2004) It is one of the most commonly used impression material in partially edentulous conditions. (Alka Patwa *et al.*, 2012; Ekanem and Akeredolu, 2004; Kenneth J. Anusavice, 2003) Due to their relative inexpensiveness, patient comfort, acceptable taste, and ease of manipulation, alginates have stood the test of time and have become an integral aspect in the practice of dentistry. (Ekanem and Akeredolu, 2004; Cook, 1986; Powers and Sakaguchi, 2006) The common use of alginate is for diagnostic cast. The diagnostic cast many times need accuracy. (Kenneth J. Anusavice, 2003; Kenneth *et al.*, 1969; Marker, 1996) The alginates lack accuracy due to poor dimensional stability and surface reproduction. The way in which the accuracy of an impression changes during the period after withdrawal from the mouth and pouring to make a cast or die is a measure of its dimensional stability. (Shaba *et al.*,

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2007) An ideal impression material should have perfect dimensional stability such that the impression would retain its original accuracy indefinitely. (Shaba *et al*., 2007) Most acceptable limits for accuracy are from 0.1% to 0.27%. Other researchers claim that a value of 50 µm is the maximum acceptable discrepancy between a master cast and a poured impression made from the master model. (Brett *et al*., 1995) The common factors that cause dimensional changes in alginate impressions are setting contraction, thermal contraction and release of internal stresses on cooling from the body temperature to room temperature. (Marker, 1996; Mc Cabe and Angus Walls, 1998) These changes can be due to inherent properties of syneresis, imbibitions and evaporation. (Kenneth J. Anusavice, 2003; Marker, 1996) The setting reaction of alginate causes replacement of monovalent ions by divalent ions result in cross-linking of the alginate chains that continues to increase after the material has set and this contributes to dimensional changes after withdrawl from the oral cavity. The dimensional stability is directly related to storage period of the alginate impression and it changes with increasing storage time. So it is highly recommended to pour the cast immediately or 10 to 15 minutes to the maximum of 30 minutes of storage after taking impression with alginate to avoid dimensional changes. So to overcome the dimensional inaccuracy, various companies have started marketing improvised or extended storage alginates, which they claim to be near equivalent to elastomers in accuracy and can bepoured after long time. (Toros Alcan *et al*., 2009) The limited scientific investigations evaluating the dimensional stability of extended-storage alginates, support manufacturers' claims of acceptable results even after 100 hours of storage period. Thus this in-vitro study was conducted to determine the dimensional accuracy of the casts obtained from three types of alginate impression materials poured after three different storage periods. The objective of this study were to determine the influence of storage period on the dimensional changes of alginate impressions.

MATERIALS AND METHODS

In this study, a custom made brass model similar to maxillary edentulous alveolar ridge CADCAM machined with three abutments (A,B,C) simulating full veneer preparations having 6o total occlusal convergence and shoulder finish line with 1mm width was used as a master model. (Alex Hoyos *et al*., 2011; Holtan *et al*., 1991) The customised abutments are present one in anterior and two in posterior region of the ridge. They had cross hair reference points on occlusal surface to facilitate future measurements (Figure 1). The impression of the master model was made using three alginate materials (1. Algitex; 71216, Dental Products India, Mumbai, India. 2. Neocolloid; 143900, Zhermack, Badia Polesine, Italy. 3.Cavex; 110321, Haarlem, Netherlands) with the help of rim-lock stock metal trays (German dental stock trays-GDC, Rim lock perforated) (Figure 4). A total of 90 impressions of the master model was made. 30 impressions were made for each group of three alginate impression materials. Casts were poured with Type IV gypsum (50589; Pearl Stone, Asian Chemicals, Gujrat, India) at three different time interval for each type of alginate, 30 minutes,12 hours and 24 hours (Figure 6). The impression procedure was made by standardising as described by Hoyos. A and Holtan with the help of impression zig. (Alex Hoyos and Karl Johan Soderholm, 2011; Holtan *et al*., 1991) The zig consists of two upper and lower square brass metal bases. The lower brass metal base consists of three parallel guide posts of same height The metal base was designed to attach the stock metal rim-lock trays of same size U-1 with a screw in repeatable reference position with two lateral metal screws to prevent the tray from lateral movements during impression procedure (Figure 2,3). To the upper metal plate, the brass master model was attached and the plate consisted of three holes corresponding to the guide post which allowed the upper plate to slide smoothly along the guide post to meet the impression tray in the lower plate. Three removable vertical metal stops were attached to the guide post to limit range of motion of the upper plate, so that, it controls the seating of master model against the tray in a consistent position for all impressions made. The upper plate was attached with a metal screw to prevent dislodgement of the plate and also to control the plate anywhere along its sliding path in the guide post.

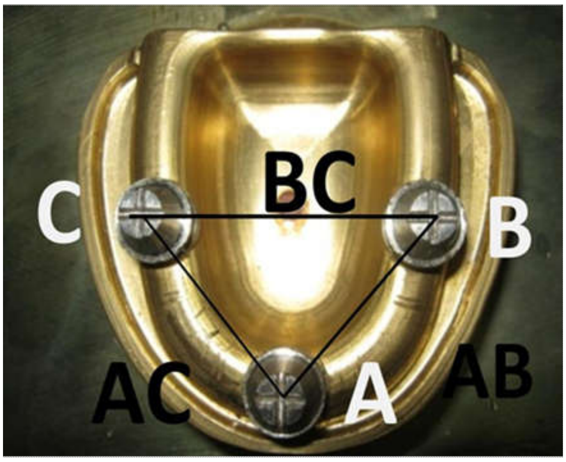

Fig. 1. Master model with abutment-a,b,c

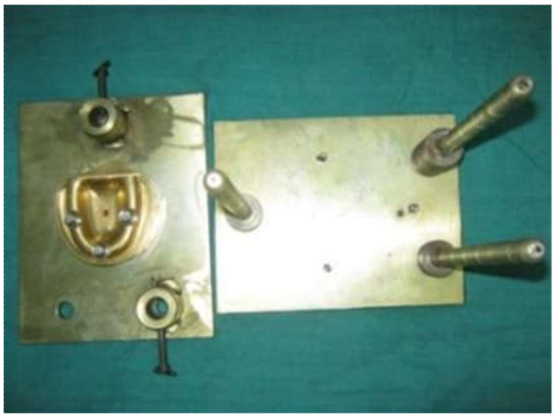

Fig. 2. Master model with impression zig apparatus

Fig. 3. Alginate impression with the zig

Fig. 4. Alginate impression of the master model

Fig. 5. Impressions stored in air sealed plastic bag

Fig. 6. Cast poured with Type IV Gypsum

Fig. 7. Dimensions measured with vernier caliper

The Master model along with the zig was taken and the rim lock tray was attached with screw on the lower plate and positioned so that the upper plate with the master model obtain a 3 mm space all around the tray by the help of vertical stops present in the guide post. The alginate impression material was then weighed and hand mixed in water/ powder ratio (Algitex-23gm/100ml distilled water, Cavex CA37-21.2gm/46ml, Neocolloid-23gm/100ml) according to manufacturer's instructions for 30 seconds and placed on the tray. The upper plate with the master model was then guided to slide slowly downwards along the post until it was stopped by the vertical stops to meet the tray with alginate impression material. The impression with the tray was kept for 1 minute until it was set and then the master model was removed from the impression in one stroke. The impression of the master model was kept in three storage period 30 minutes, 12 hours and 24 hours in an air tight packet with a wet cotton roll inside to achieve a 100% relative humidity (Figure 5). Type IV dental stone–Die stone (Pearl Stone, Asian chemicals, Gujrat, India) was hand mixed for 10 to 30 seconds using 25 ml of distilled water per 100g of gypsum powder and poured. After 45 mins (final set), the gypsum cast was retrieved. All cast fabrication was done by single operator. The linear dimensions between the three abutments in the master model and in the casts obtained were measured with help of a electronic vernier caliper (Mitutoyo, Kawasaki, Japan 0.01mm accuracy). The interabutment distance between the junction of cross hair lines of AB, AC and BC were measured (Figure 7).

The One way analysis of variance were used (ANOVA) for comparison of dimensional accuracy of cast obtained from the three types of alginate impression materials after three different storage periods. The level of significance was set at $p<0.05$.The mean linear measurement of the inter-abutment distance in the master model are AB-30.40 mm, AC-30.41 mm, BC39.80 mm. These linear measurements are compared in the result with the casts obtained from the three alginate impression materials in different pouring time.

RESULTS

The mean value of each inter-abutment distance AB,AC,BC of all three alginate impression materials at three different storage periods were tabulated and statistically analysed (Table I,II,III). At 30 minutes of storage period there was no significant difference in dimensional changes between the three alginates $p>0.05$ (Table IV).At 12 and 24 hours of storage period significant dimensional changes were found between the three alginates $p<0.05$ (Table V, VII). Thus multi comparison test had been done in 12 and 24 hours to find out the alginates undergone most dimensional changes (Table VI,VIII). It was found that Cavex CA37 had undergone the least dimensional changes than the other two alginates in comparison with the dimensions of master model (Table VI,VIII).

DISCUSSION

Considering the material itself, the irreversible hydrocolloid impression materials have lower dimensional stability The discrepencies detected for these materials can be due to expansion by water absorption (imbibition), shrinkage due to evaporation of water (syneresis) and relief of internal stresses. (Kenneth J. Anusavice, 2003; Cook, 1986). Three alginate materials –one conventional alginate –Algitex and two

Table I. Frequency Distribution Table for Algitex (mm)

	Mean	SD	SEM	Minimum	Maximum
30Min-AB	30.400	0.0115	0.0036	30.38	30.42
30Min -AC	30.399	0.0099	0.0031	30.38	30.41
30Min- BC	39.807	0.0105	0.0033	39.79	39.82
12hrs-AB	30.501	0.0099	0.0031	30.49	30.52
12hrs -AC	30.567	0.0116	0.0036	30.55	30.59
12hrs - BC	40.054	0.0069	0.0022	40.04	40.06
24hrs-AB	30.562	0.0078	0.0024	30.55	30.57
24hrs -AC	30.600	0.0115	0.0036	30.58	30.62
24hrs - BC	40.061	0.0073	0.0023	40.05	40.07

SEM=Standard Error of Mean; SD=Standard Deviation

Table II. Frequency Distribution Table for Neocolloid (mm)

	Mean	SD	SEM	Minimum	Maximum
30Min-AB	30.400	0.0115	0.00365	30.38	30.42
30Min -AC	30.403	0.0116	0.00367	30.38	30.42
30Min- BC	39.804	0.0126	0.00400	39.78	39.82
12hrs-AB	30.426	0.0084	0.0026	30.41	30.44
12hrs -AC	30.426	0.0084	0.0026	30.41	30.44
12hrs - BC	39.856	0.0069	0.0022	39.85	39.87
24hrs-AB	30.561	0.0073	0.0023	30.55	30.57
24hrs -AC	30.602	0.0131	0.0041	30.58	30.62
24hrs - BC	39.879	0.0166	0.0052	39.85	39.90

SEM=Standard Error of Mean; SD=Standard Deviation

Table III. Frequency Distribution Table for Cavex (mm)

	Mean	SD	SEM	Minimum	Maximum
30Min-AB	30.399	0.0119	0.0037	30.38	30.42
30Min -AC	30.403	0.0141	0.0044	30.38	30.43
30Min- BC	39.798	0.0113	0.0035	39.78	39.82
12hrs-AB	30.412	0.0168	0.0053	30.38	30.43
12hrs -AC	30.406	0.0157	0.0049	30.38	30.43
12hrs - BC	39.818	0.0161	0.0051	39.79	39.84
24hrs-AB	30.417	0.0094	0.0030	30.40	30.43
24hrs -AC	30.411	0.0179	0.0056	30.38	30.44
24hrs - BC	39.807	0.0094	0.0030	39.79	39.82

SEM=Standard Error of Mean; SD=Standard Deviation

Table IV. Group Comparison of interabutment distance after 30 min

Parameters	df	F	p Value
Length 1(AB) **Between Groups** **Within Groups**	3.36	0.024	0.995
Length 2(AC) **Between Groups** **Within Groups**	3.36	1.926	0.143
Length 3(BC) **Between Groups** **Within Groups**	3.36	1.620	0.202

One- Way ANOVA; df= Degree of Freedom

Table V. Group Comparison of interabutment distance after 12Hrs

Parameters	**df**	**F**	**p Value**
Length 1(AB) **Between Groups** **Within Groups**	336	182.07	0.000¶
Length 2(AC) **Between Groups** **Within Groups**	336	521.68	0.000¶
Length 3(BC) **Between Groups** **Within Groups**	3 v36	1521.48	0.000¶

One- Way ANOVA; df= Degree of Freedom, ¶ = $p<0.001$=very highly significant(VHS)

Table VI. Group Comparison of interabutment distance after 12Hrs

	Algitex	Neocolloid	Cavex	Master
Length 1(AB)	30.501$^{b\P c\P d\P}$	30.426$^{a\P c* d\P}$	30.412$^{a\P b*}$	30.400$^{a\P b\P}$
Length 2(AC)	30.567$^{b\P c\P d\P}$	30.426$^{a\P c\dagger d*}$	30.406$^{a\P b\dagger}$	30.410$^{a\P b*}$
Length 3(BC)	40.054$^{b\P c\P d\P}$	39.856$^{a\P c\P d\P}$	39.818$^{a\P b\P d\dagger}$	39.800$^{a\P b\P c\dagger}$

One-Way ANOVA: Post Hoc Multiple Comparisons

*=$p<0.05$= statistically significant (SS); † =$p<0.01$= Highly Significant (HS); ¶=$p<0.001$= Very Highly Significant (VHS); a = compared with Algitex; b = compared with Neocolloid; c = compared with Cavex; d =compared with Master.

Table VII. Group Comparison of interabutment distance after 24 Hrs

Parameters	Df	F	p Value
Length 1(AB) **Between Groups** **Within Groups**	336	1519.61	0.000¶
Length 2(AC) **Between Groups** **Within Groups**	336	770.81	0.000¶
Length 3(BC) **Between Groups** **Within Groups**	336	1402.91	0.000¶

One- Way ANOVA; df= Degree of Freedom

¶= P<0.001=VHS= very highly significant

Table VIII. Group Comparison of interabutment distance after 24 Hrs

	Algitex	Neocolloid	Cavex	Master
Length 1(AB)	30.562[c¶d¶]	30.561[c¶d¶]	30.417[a¶b¶d¶]	30.400[a¶b¶c¶]
Length 2(AC)	30.600[c¶d¶]	30.602[c¶d¶]	30.411[a¶b¶]	30.410[a¶b¶]
Length 3(BC)	40.061[b¶c¶d¶]	39.879[a¶c¶d¶]	39.807[a¶b¶]	39.800[a¶b¶]

One-Way ANOVA: Post Hoc Multiple Comparisons

¶= P<0.001=VHS= very highly significant; a = compared with Algitex, b = compared with Neocolloid; c = compared with Cavex; d = compared with Master

improvised alginate- Neocolloid and Cavex CA37 were taken These are taken in reference to previous studies where they compared the dimensional accuracy of conventional alginates with extended storage and found that the later gives more accurate dimensions than the former. (Mary P. Walker *et al*., 2010) In this study the storage period for the alginate impressions were 30 minutes, 12 hours, 24 hours. Based on the previous studies by Walk.P.M, the maximum recommended storage time of conventional alginate before pouring the cast is ranged from immediately to up to 30 minutes of storage. (Mary P. Walker *et al*., 2010; Deepa *et al*., 2010) Many authors have found that extended storage alginate impressions can be poured delayed up to 5 days and gives less dimensional changes if stored properly (Skinner and Pomes, 1946; Terence A. Imbery *et al*., 2010). It was found that the dimensional changes of alginate impressions at 12 hours and 24 hours are 0.06 % and 0.13 % respectively. 18 The previous studies shows that the linear dimensional changes of the impressions caused due to evaporation and imbibition of water if stored outside the environment. This can be prevented if stored in 100% relative humidity. The sealed plastic bag was used in this study are customised by keeping wet cotton inside the bag without contact with the impression or sprinkling water droplets inside the plastic bag in order to get 100 % relative humidity The brass master model used in this study were similar to that made by Alex Hoyos al. (Alex Hoyos and Karl Johan Soderholm, 2011) The brass master model is rigid, water insoluble and thus taken as control group that does not undergo change in dimensions at any storage time. The impression apparatus used in this study was standardised and customised from that described by Holtan and Alex (Alex Hoyos and Karl Johan Soderholm, 2011; Holtan *et al*., 1991) This is done to maintain an uniform thickness and minimizing the lateral stresses on the alginate impressions during taking out and thus preventing from dimensional changes. (Danish Muzaffar *et al*., 2011)

In the present study, stock metal rim lock perforated trays of similar size were used for all the impressions (Farzin and Panahandeh, 2010; Luis J. Rueda *et al*., 1996). This is due to the rigidity of the tray that can prevent from distortion during removal from the model it as reported by Lueda and Hoyos (Alex Hoyos *et al*., 2011; Mendez, 1985; Luis J. Rueda *et al*., 1996) Dimensional stability is the ability of a material to maintain accuracy across time. (Nicholls, 1977) The process that influences dimensional stability are the gelation properties and viscoelastic behaviour resulting in net expansion or shrinkage of the impressions followed by undersized or oversized casts. (Terence A. Imbery *et al*., 2010) In this study, no significant difference in dimensions among the conventional and extended storage alginates were found at 30 minutes of storage time. This could be due to the fact that the elastic recovery of all the impressions takes place within 30 minutes. (Deepa *et al*., 2010) At 12 and 24 hours conventional alginate shows greater dimensional changes than the extended storage alginates. The loss of water from the interior of the material collapses the fibrillar cross-linked network (Stéfani Becker Rodrigues *et al*., 2012) and contraction of the impressions occurs towards the wall of the tray making the reference point to move farther apart (Brett.I.Cohen *et al*., 1995; Chiranjeevi Reddy *et al*., 2010; Terence A. Imbery *et al*., 2010). The extended storage alginates shows very less dimensional discrepencies at 12 and 24 hours. This is due to the fact that these alginates contain higher calcium to sodium ratios, high mannuronic acid content, higher ratios of filler to alginic polymer, differences in bound to unbound water, lower weight molecular-polymer chains, acidic pH, sufficiently high elastic limit and increased compressive strength. (Terence A. Imbery *et al*., 2010) The higher ratios of filler in the ingredients offers greater gel strength, helps in bound of water inside the gel resulting in less shrinkage and distortion. (Fellows and Thomas, 2008) The manufacturers have developed these improved "non shrinking" hydrocolloids simply by fine tuning of these parameters with addition of osmotic effective ingredients like crystalline sodium sulphate.31In this study, Cavex CA37 shows most dimensional accuracy than others followed by Neocolloid and Algitex, Cavex has 83.3 % filler particles and higher ratios of Ca: Na ratios in its ingredients31. The Cavex has also high elastic recovery of about 97% greater than recommended ISO1563 and A.D. Astandard 18.Many researchers though found the best dimensional stability of the alginate impression material, if poured immediately The results of our study and indicate that extended storage alginates – Cavex CA37, Neocolloid provides better dimensional stability than conventional alginate in extended pouring time if stored properly. Some limitations of this study can be identified. First the metal master model was used with least number of undercuts to prevent from distortion during impressions. Clinically undercuts in mouth can cause more distortion. Second, impressions were not subjected to disinfection procedure that might cause dimensional change. Third using stock tray instead of custom tray may affect in dimensions. Additional research in future is needed to determine how newer improvised alginate materials would respond to similar treatments.

Conclusion

Within the limitation of this in-vitro investigation the following conclusions can be drawn:

1. All three alginate impression materials shows no significant difference in dimensional changes at 30 minutes storage period in comparison to very high significant difference at 12 hours and 24 hours of storage period
2. Improvised or extended storage alginates like Cavex CA 37 shows higher dimensional stability than other two conventional alginate neocolloid and algitex at all three storage period
3. The mean values of dimensions in general increases with storage time for all alginates, so to obtain best dimensional stability, immediate pouring is recommended

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